CHAPTER 6

Building Institutions for a Better Environment

The United States has achieved dramatic improvements in environmental quality over the past 30 years. Toxic releases have been reduced since they were first widely reported in 1987, waters safe for fishing and swimming have doubled, and air quality has improved markedly. This trend toward a cleaner, healthier environment, repeated in many of the world's other developed countries, is reflected in various indicators of environmental quality, including measures of sulfur dioxide, lead, and carbon monoxide emissions. Box 6-1 shows how emissions of these and other air pollutants have fallen significantly in the United States, with similar gains in a host of other countries.

These improvements are the result of policies that sought to address some of the most obvious risks to human health posed by air and water pollution, leakage from hazardous waste sites, and unnecessarily damaging mining and other extractive practices. In these early initiatives, the benefits often far outweighed the costs. Now that most of the largest and most glaring environmental problems have been tackled, however, the gains to be expected from further measures have become less obvious and more contentious. Meanwhile competition for resources and for the attention of policymakers and concerned citizens is as keen as ever. Medical research, national security, education, capital investment, and consumption all make valid claims on both government and private resources. As the environmental issues we address become ever more complex, research and careful analysis of both benefits and costs are required to formulate responsible policies that will improve Americans' well-being and are cost-effective.

Put another way, the task now before us is to build the right institutions to address these increasingly thorny environmental issues. For example, there is evidence that further improvements in air quality would improve health and reduce mortality, but these improvements might be extremely expensive. Similar tradeoffs are associated with reductions in certain toxic substances, such as arsenic in drinking water and mercury from the burning of coal. Although the health benefits from further reductions in these pollutants are surely desirable, the associated expense might be better directed toward alleviating other problems with the potential for even larger reductions in health risks. Ongoing efforts to protect endangered species, maintain biodiversity, and preserve ecosystems—all of which can influence long-term land use decisions and short-term economic activity—could pose tradeoffs between the welfare interests of current and future generations. Finally, concern over

Box 6-1. Trends in National and International Environmental Quality

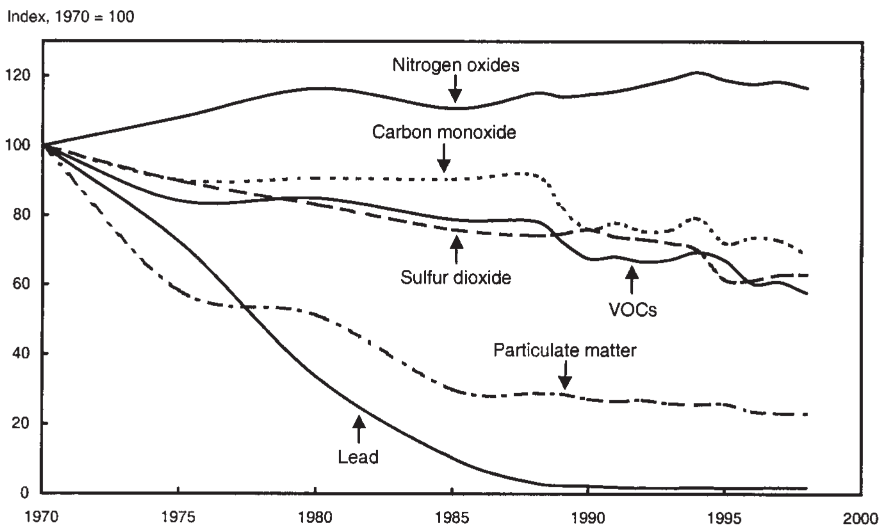
Some of the most dramatic improvements in environmental quality have occurred in the air we breathe (Chart 6-1). The 1970 Clean Air Act Amendments identified six common, nationwide air pollutants for which emission limits were needed in order to achieve certain ambient concentration levels based on health criteria. Since the law was passed, emissions of most of these “criteria air pollutants” have declined significantly. Perhaps the most impressive achievement is the near elimination of lead emissions, which by 1998 were only 2 percent of their 1970 level.

One criteria air pollutant whose emissions have not fallen is nitrogen oxides, and one might be tempted to conclude that environmental quality with respect to this pollutant has gotten worse. But in fact the story of nitrogen oxides regulation highlights the importance of using the appropriate metrics in judging environmental quality: although emissions of a pollutant are often reported, it is ambient concentrations in the air we breathe that affect us directly and are the target of most environmental regulation. In the case of nitrogen oxides, and indeed for all criteria air pollutants, average national concentrations have fallen in the past 20 years (Chart 6-2).

In addition to these reductions in criteria air pollutants, regulations and voluntary actions on the part of companies have resulted in substantial reductions in 188 toxic air pollutants that are either known or suspected to cause cancer or have other serious health effects. Nationwide emissions of these pollutants in 1996 were 23 percent below levels measured earlier in the decade. Concentrations of some of these toxic air pollutants have been reduced even more dramatically.

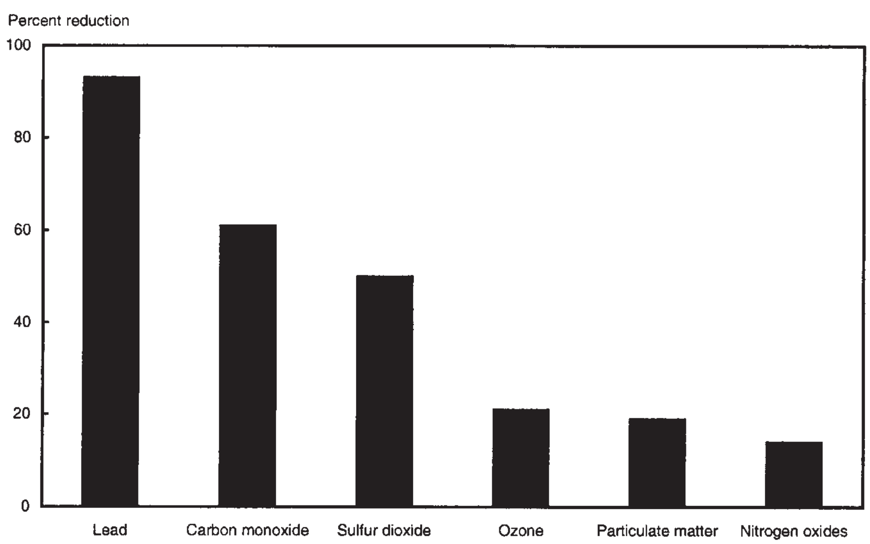
For many pollutants, such as sulfur dioxide, trends in the United States mirror those in other industrialized countries (Chart 6-3). The downward trend in such emissions is particularly impressive given the substantial growth in national income over the same period. Although it is sometimes assumed that economic growth leads to environmental degradation, studies show that environmental improvements usually accompany national income growth at higher levels of income, an observation that the chart supports.

Chart 6-1 **Emissions of Major Air Pollutants**
Emissions of most major air pollutants have fallen, some spectacularly, since the passage of the 1970 Clean Air Act Amendments.



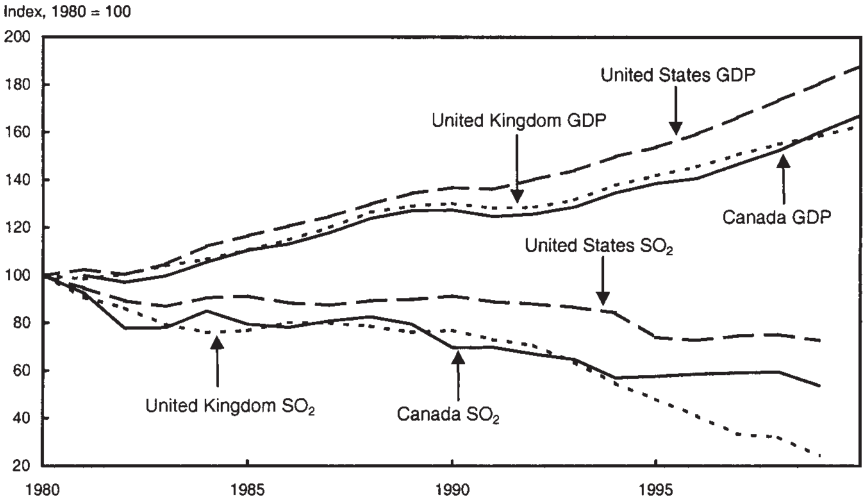
Note: VOCs are volatile organic compounds. Particulate matter refers to particles no greater than 10 micrometers in diameter and does not include miscellaneous or natural sources.
Source: Environmental Protection Agency.

Chart 6-2 **Reductions in Average Ambient Concentrations of Major Air Pollutants, 1981-2000**
Atmospheric concentrations of all six major pollutants have declined over the past 20 years.



Note: Data for particulate matter (as defined in Chart 6-1) begin in 1991. Reduction for ozone is that of one-hour levels.
Source: Environmental Protection Agency.

Chart 6-3 **Sulfur Dioxide Emissions and GDP in Canada, United Kingdom, and United States**
Sulfur dioxide emissions have declined in the United States and other countries alongside substantial growth in GDP.



Note: GDP data for Canada begin in 1981.
Sources: Department of Commerce (Bureau of Economic Analysis), EMEP Program (Co-operative Program for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe), Office for National Statistics (United Kingdom), and Statistics Canada.

potential climate change poses perhaps the greatest challenge. Sound climate change policy requires striking a balance not only between the well-being of current and future generations, but across countries as well. Choices must be made in the face of considerable scientific uncertainty and alongside competing concerns about energy security and diversity of fuels.

In many of these issues, the debate is frequently cast in terms of a tradeoff between environmental protection and economic growth. Yet the two are not necessarily mutually exclusive. As a society becomes more affluent, it is likely to demand a cleaner and safer environment. Prosperity also allows us to commit ever-increasing resources to environmental protection and to the development of science and technology that will lead to both future growth and a better environment. Indeed, empirical evidence suggests that growth eventually goes hand in hand with environmental improvements.

The design of appropriate institutions plays an important role in improving environmental quality; in particular, flexible approaches to environmental regulation can increase the benefits and lower the costs relative to alternative schemes. Such approaches often allow businesses to pursue established environmental performance goals or emission limits in the ways that they find most effective, rather than following specific, detailed government mandates. This flexibility encourages innovation and the development of cleaner technologies. Over time, flexible approaches and other programs that promote technological innovation offer the promise of less pollution at even lower costs. The President's National Energy Plan, for example, builds on these ideas by encouraging both increased flexibility in regulation and the development of clean technologies.

Flexible programs also often involve a smaller, less costly regulatory and compliance apparatus. In place of lengthy wrangling and resorting to legal action between business and government over the interpretation and applicability of particular rules, requirements, and regulations, flexible approaches allow markets, financial incentives, and business-to-business transactions to efficiently allocate resources with minimal government supervision.

By institutions we mean not only the formal rules, regulations, markets, monitoring, and administrative features developed for environmental protection, but also the informal knowledge, experience, and norms that are essential for effective outcomes. Institutions of this kind that embody the flexible approaches described above do not appear overnight. Part of the challenge for environmental protection is designing and building the best institutions for the various problems we confront today, but another part is carefully constructing those institutions so that they can evolve to deal with emerging problems tomorrow. In exploring ways we can build institutions for a better environment, this chapter considers the pros and cons of alternative flexible mechanisms such as tradable permits, tradable performance standards, and emission charges. Several case studies of alternative schemes then illustrate these mechanisms in practice. Finally, we consider how this experience can be applied to the pressing environmental concern over the potential threat of climate change. We begin by briefly examining the motivation behind government involvement in environmental protection.

The Government's Role in Environmental Protection

At a basic level, environmental amenities have characteristics that frequently make them more of a public than a private responsibility. First, many environmental resources—notably the atmosphere, the oceans, and underground aquifers—are shared without becoming the exclusive property of anyone. Second, how one individual or business chooses to use air, water, and land resources influences the value of those common resources for many others. For example, marine fisheries are an important food source, but excessive commercial fishing reduces the ability of a fish population to reproduce and provide more fish next season. Coal combustion provides an inexpensive and reliable source of energy, but the resulting emissions of sulfur dioxide (SO_2) increase the acid content of lakes and forest soils. Lead in gasoline is a convenient catalyst for boosting automobile performance, but it has adverse effects on children exposed to the consequent emissions from vehicles.

Economists refer to these environmental resources—healthy fisheries, healthy lakes and forests, and clean air—as public goods, and to the unintended, adverse effects resulting from the use of those resources as externalities. More broadly, externalities are the uncompensated effects of the activities of one individual or group on another: because these effects have no financial consequences for the individual or group undertaking the activity, they are external to the market. For example, until the government intervened, those who overfished a fishery did not bear the cost of that depletion to other fishermen and consumers; the power plants that emitted SO_2 had no financial incentive to reduce those emissions; and the refiners and users of gasoline faced no constraints on their use of lead as a catalyst. All these consequences were external to the market transactions that caused them and in some cases were not even appreciated at first. Even when they are identified and understood, however, such externalities by themselves are not necessarily a cause for government intervention. So long as the externality is identified, the individuals affected can, in theory, negotiate a solution. In our examples, some fishermen could have paid others not to overfish, the users of acidifying lakes and forests could have paid power plants to reduce SO_2 emissions, and communities could have negotiated with refineries to reduce the lead in gasoline.

The improbability of such solutions in the real world, however, highlights the fact that the corresponding problems, and environmental issues more generally, all involve public goods to some degree. This complicates arriving at a privately negotiated solution, because it is difficult to exclude those unwilling to pay to help solve these problems from enjoying the benefits of the improved resource. The productiveness of the fish stock, the recreational and commercial value of lakes and forests, and the health improvements from reduced lead emissions are all benefits that many if not all people can enjoy simultaneously and that are difficult to exclude people from enjoying. Under these circumstances, no single individual has the private incentive to negotiate a socially beneficial solution, because most of the benefits go to others. Nor is it easy for groups of individuals to band together informally to pursue a solution, because each has an incentive to "free ride," allowing others to take care of—and pay for—the problem. Here the government can play an important role by representing the interests of a large group of individuals and compelling all those interested to share in the cost.

Measuring the Benefits and Costs of Environmental Protection

Rectifying an environmental problem—pollution in a river, for example, or depletion of a fishery—requires choosing both the appropriate level of control or use and the institution best suited to implement the controls. The level of control for many pollution problems has traditionally been set with an eye toward benefits. A prime example is air quality, where the Supreme Court recently upheld a decision that national air standards must be set to protect the public health without regard to costs, as set forth in the 1970 Clean Air Act Amendments. At the time this and other early statutes were passed, it may have appeared that the benefits were desirable at any cost, or that the costs were low, removing the need to consider them. However, as production technologies have become increasingly clean, the further reduction of pollution has become more difficult, and costs have risen. As a result, concern over costs has entered the regulatory process: levels of control on hazardous air pollutants are based not only on health concerns, but also on what control technologies are available. This means that consideration is given to whether the level chosen is feasible and cost-effective enough that someone has already developed technology for it. Costs also play a role in some fishery management policies, where the permitted annual harvest is set to maximize the sustainable catch.

Comparing the benefits and the costs of environmental policies is important because of the many competing needs for public and private expenditures. The optimal level of environmental protection is that where the benefit associated with one more unit of the resource equals the cost of providing it, with both benefits and costs appropriately added up across all individuals and over time. What should we include in our cost and benefit measures? On the cost side, most expenses associated with environmental protection arise from the use of marketed goods and services, making calculations relatively straightforward. For example, it is estimated that the recent decision by the Environmental Protection Agency to lower the acceptable level of arsenic in drinking water from 50 to 10 parts per billion will impose a total annual cost of more than $200 million. This $200 million will then be unavailable for other private and public activities—including other health and environmental programs. This therefore represents the cost of the program, which can then be compared with the benefits. Note that in the arsenic case—as well as in two of the case studies later in this chapter—concern over the distribution of costs and benefits was a particularly thorny issue, even though in theory it should be possible to make everyone better off when the overall benefits outweigh the costs.

The choice of policies and institutions to be used in achieving the environmental objective also plays an important role in determining costs. For example, cost estimates associated with implementing the Kyoto Protocol vary by orders of magnitude, depending on assumptions about the effectiveness of trading institutions. These trading institutions allow countries with higher abatement costs to seek out reductions in other countries with lower abatement costs. Because certain institutions—specifically, those that provide flexibility—offer the opportunity to achieve environmental goals at lower cost, it is important to understand the differences among the major types of environmental regulation, to which we return below.

On the benefits side, gains from environmental protection are often divided into two categories: use value and nonuse value. Use value refers to benefits that occur when individuals come into direct contact with the protected environment. These benefits may be associated with marketed goods and services, such as admission or transportation fees, or nonmarketed activities such as hiking, swimming, camping, or just looking at a beautiful natural landscape. They also include the health consequences of breathing cleaner air and drinking cleaner water. Nonuse value, which often involves nonmarketed goods and services, refers to the less tangible benefits that arise from individual preferences with respect to environmental amenities, as distinct from their direct use. This includes the value derived from knowing that a resource has been maintained and will be available to future generations, or to oneself if one should ever decide to use it.

Use values associated with marketed goods and services can often be estimated from observed behavior. For example, the willingness of people to pay to use a national park—as measured by the entrance fees they actually pay, or their travel expenditure to get there—can be used to estimate the value they associate with the park. Wage studies measuring the pay difference between low-risk and high-risk jobs can be used to infer the value associated with prolonged life, which can then be used to evaluate health-enhancing environmental proposals. Expenditures on water filters or bottled water can be used to value a reduction in water pollution. Nonuse values, as well as use values that are not associated with market activities, are more difficult to estimate accurately. Typically, individuals are surveyed and asked to place a dollar value on hypothetical levels of environmental quality, such as better visibility in scenic areas or enhanced protection of wilderness, ecosystems, and biodiversity. This approach is still a subject of scholarly research.

Types of Environmental Regulation

The policies and institutions used to achieve an environmental goal often have significant consequences for the associated cost. As environmental regulation has evolved, businesspeople and policymakers have worked together to find more flexible approaches that achieve the same goal at significant savings. These approaches range from standard tradable permit and fee programs, to more complex tradable performance standards and hybrid permit/fee programs, to more informal, flexible regulatory arrangements.

Command-and-Control Approaches

Traditional regulations for environmental protection, such as those legislated under the 1970 Clean Air Act Amendments, focused on developing specific technology and performance standards for pollution sources to meet. Technology standards mandate specific equipment that sources must use to control emissions, whereas performance standards mandate a limit on emissions allowed by each source. Because technology standards typically require the same technologies for all sources, and performance requirements require the same level of emission reductions or emission rates at all sources, both these approaches fail to take advantage of differences in the circumstances of each source. In particular, they fail to encourage more reductions where the cost of such reductions is low, and fewer reductions where the cost is high. Over the years, numerous studies have documented the added expense of limiting this kind of flexibility, with cost estimates of traditional regulation ranging from as little as 7 percent to as much as 2,200 percent (that is, 22 times) more expensive than an efficient, flexible program.

Standard Market-Based Approaches: Permit Trading and Fees

In the cases of marine fisheries, SO_2 emissions, and leaded gasoline noted earlier, market-based policies have been used to provide greater flexibility in meeting particular environmental goals. Fishermen, power plants, and gasoline refiners were required to hold a volume of permits (also referred to as allowances or quotas) equal, respectively, to the volume of fish caught, emissions created, or lead blended into gasoline. These permits were distributed on the basis of either past or current production. Unlike the earlier, command-and-control approaches, however, these permits could be freely traded, creating highly efficient markets in which firms holding more permits than needed could sell them to others or, in some cases, hold onto them for future use.

These permit markets have many advantages. They ensure that the most valuable uses of the affected resources are encouraged, they maximize economic activity and growth consistent with a given level of pollution reduction, and they encourage innovation in solving the environmental problem at hand. In addition, the market price of the permits provides a clear signal about the economic value of the environmental resource, which can then be used for both business planning and policy evaluation. Finally, although the permits in these programs were predominantly distributed freely to predetermined stakeholders, the government could choose in future programs to sell the permits, generating revenue that could be used to reduce taxes on capital and labor, thus improving the efficiency of the tax system.

Emission fees, where businesses pay a fee for each unit of emissions rather than buy and sell permits, share many of the advantages of tradable permits. They provide an incentive to engage in only the most valuable uses of the environmental resource, send a clear signal about its economic value, and generate revenue that can be used to reduce other taxes. Emission fees, however, provide greater certainty to businesses because the price associated with emissions (the charge rate) is fixed. In contrast, because tradable permits are in fixed supply, their price can fluctuate to reflect changes in demand—sometimes substantially. As an example, a market for nitrogen oxides (NO_x) emission permits was established in 1994 in the area around Los Angeles. At the end of 1999, permits for use in 2000 traded for around $2 a pound, but by August 2000, during California's emerging electric power crisis, they sold for as much as $50 a pound. Of course, the greater price certainty associated with emission fees comes at a cost: under an emission fee the actual level of emissions can fluctuate. Thus emission fees make it trickier for regulators to achieve a targeted level of emissions. Tradable permits also allow an administratively easier redistribution of the value associated with emission rights. Revenue from a permit fee can be rebated and redistributed, but this requires the government to distribute money after collecting fees, thus involving the government in myriad financial transactions. Under a tradable permit system, permits can be distributed in advance of the actual program, and financial transactions need occur only among private firms and individuals. Perhaps because of this, emission fees have received little attention in the United States, despite their considerable popularity in other countries (Box 6-2).

An intriguing possibility is the coupling of a tradable permit system with a fee-based "safety valve." In this hybrid scheme, a regulatory agency operating an ordinary tradable permit program would create and sell extra permits on request at a fixed fee. If the fee were set above the typical trading price—for example, above the $2 a pound price that prevailed before 2000 in the Los Angeles NO_x permit market—it would ordinarily not interfere with the permit market. However, in the event of an unusual demand spike like that

Box 6-2. Environmental Fees in Other Countries

Whereas the United States has tended to use tradable permits to encourage cost-effective reductions of pollutants, market-based environmental regulation in other developed countries has more commonly relied on fees, with particular focus on the transportation sector. For instance, in 1995 about 90 percent of the revenue from pollution control-related fees in 20 industrial countries came from fees on gasoline, diesel fuel, and motor vehicles. In the last decade, however, some European countries have developed fees specifically designed to reduce particular industrial pollutants.

In 1992 Sweden introduced a charge on NO_x emissions from large combustion power plants. This fee of 40 Swedish krona per kilogram of NO_x emissions, equivalent to about $4 at the current exchange rate, was extended to smaller power plant boilers in 1996. Revenue from this fee is returned to the group of power plants that pay them in proportion to each plant's share of total energy production. This refund reduces the total financial burden on power plants from the fee. But the fee still provides an incentive to reduce NO_x emissions whenever the cost for each unit reduced is less than the fee. The Swedish government estimated that in 1995, as a result of the fee, NO_x emissions from power plants declined by 20 percent.

A Danish experiment with fees highlights one problem common to many existing environmental fees. In 1992 Denmark introduced a fee on carbon dioxide (CO_2) emissions by households, which was followed in 1993 by a similar fee on CO_2 emissions by industry. As a result of concern about the effect of these fees on Danish industrial competitiveness, the fees were altered in 1995 so that certain energy-intensive industries paid lower fees on CO_2 emissions than did less energy-intensive industries. Although this change had the desired effect of reducing the burden on the more energy-intensive industries, it also reduced the cost-effectiveness of the emission reduction scheme overall.

Firms facing CO_2 fees will reduce emissions up to the point where the cost of reducing another unit of emissions (that is, the marginal cost) equals the fee. Beyond that level it is cheaper to simply pay the fee than to further reduce emissions. Because different firms face different fees in Denmark, they should end up with differing marginal costs as well. This implies that the present arrangement is inefficient, because the total cost of the prevailing level of emission reduction could be reduced. Shifting some responsibility for emission reduction from firms facing high marginal costs to those facing lower marginal costs would lower the overall burden.

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Box 6-2.—*continued*

The Danish experience is not unique, however: throughout the industrialized world, environmental fees have frequently been accompanied by exemptions for particular products or industrial sectors. The goal of some of these exemptions, to reduce the burden of these fees on particular activities or sectors, can be achieved through other means that do not reduce the overall cost-effectiveness of the fee program: the revenue can be redistributed or rebated to program participants. The administrative and practical difficulties with such a redistribution point to an advantage associated with tradable permits: their initial allocations can be conducted in a way that alleviates burdens where desired.

resulting from the California energy crisis, the fee would provide additional flexibility and price stability, protecting both industry and the economy. In point of fact, California enacted something like this—whereby a reserve of NO_x permits would be available at $7.50 a pound—after last year's permit shortage. Features like this have been used in the SO_2 trading program and in regulations for heavy-duty engines, both discussed below.

Other Flexible Approaches: Informal Markets and Tradable Performance Standards

In some cases it may be impractical to implement either an emission fee or a permit trading program. For example, monitoring actual emissions may be too expensive to make either viable. Emission fees also face opposition because they impose on regulated firms the burden of fee payments in addition to pollution control costs. At the same time, tradable permits may be impractical because the transactions costs associated with trading are too high, because there are too few potential buyers or sellers, or because different levels of sophistication among potential market participants are likely to lead to inefficiencies.

In these situations, alternative institutions can arise that approximate the efficiency of true market approaches by providing flexibility, but trade off some of the potential economic gains in the face of these practical constraints. One approach, discussed later in the Tar-Pamlico case study, is a less formal trading market. Another is a tradable performance standard.

The regulation of nitrogen oxides, particulate, and hydrocarbon emissions from various types of combustion engines provides multiple examples of how a tradable performance standard can work. Since 1991, heavy-duty, on-highway engine manufacturers (who produce the engines used in trucks and buses) have been able to comply with some of these emission standards on new engines through a combination of averaging, banking, and trading—or ABT. This approach has been extended to emission standards for many other types of engines, including outboard boat engines, automobile and light truck engines, locomotives, and small nonroad engines such as lawn mowers.

A typical ABT program begins with a schedule of emission standards. For example, the NO_x standard for heavy-duty, on-highway diesel engines started at 6 grams per brake horsepower-hour for engines made in 1990, falling to 5 grams in 1991 and 4 grams in 1998. After 2004, even stricter standards will be applied. These are performance standards in the sense that they specify emissions (grams of NO_x) in relation to other outputs—in this case useful mechanical energy output measured in brake horsepower-hours. Engine manufacturers who lower their engines' emissions beyond the standard generate credits. The number of credits is related to how much lower the emissions are, over the life of the engine, than those for an engine that exactly meets the standard. With some restrictions, manufacturers that earn credits can use them to offset excess emissions from current-year engines that do not meet the emission standard (averaging), reserve them for similar use in future years (banking), or sell them to other manufacturers (trading).

Compared with a program that requires all engines to meet the same standard, these ABT programs make it possible to achieve the same (or lower) emissions at a lower cost. The banking element encourages manufacturers to overcomply in order to generate a stock of credits, providing flexibility in the future. This overcompliance reduces emissions below the standard in the current year. At the same time, the flexibility to produce some engines that do not meet the standard and others that surpass it—while achieving the standard on average—allows manufacturers to reduce emissions more among those engines where control costs are lower.

The program for heavy-duty, on-highway engines contains an additional flexibility mechanism called a nonconformance penalty. Manufacturers that fail to meet the standard, and fail to obtain credits from other sources, can choose to pay a penalty based on the degree to which their engines exceed the standard. As an example, in 1991 a manufacturer producing a heavy-duty diesel engine that was certified at 6 grams of NO_x per brake horsepower-hour (when the standard was 5) could have paid a penalty of about $1,600 for each engine rather than seek out emission credits. The nonconformance penalty limits the maximum costs that can be incurred by manufacturers seeking to comply with the regulation, providing them an additional measure of financial certainty. True, unlike the ABT mechanisms, which can lead to lower emissions than the required level, this kind of penalty (if used) allows emissions to rise relative to a program requiring strict adherence to the standard. However, this flexibility may actually allow the adoption of tighter standards, suggesting that such a straightforward comparison is not valid.

Myths About Flexible Approaches

Despite the demonstrated benefits of flexible programs, popular concern remains. Some of these concerns raise valid distributional and equity issues. The economic and environmental benefits of flexible programs are not always shared equally, and indeed, some stakeholders can end up worse off. But other concerns derive from misperceptions about how flexible approaches work. These misperceptions can be addressed by better information. Below we discuss some of the more common myths surrounding flexible approaches to environmental regulation, and counter them with rational economic explanations.

Myth #1: "It's immoral to buy the right to pollute."

A widely held belief is that it is somehow unethical or even immoral to allow firms to buy and sell the right to pollute. For example, it has been claimed that turning pollution into a commodity to be bought and sold removes the moral stigma properly associated with it, and makes pollution just another cost of doing business, like wages, benefits, and rent. Regarding climate change, it has also been asserted that an emission trading program may actually undermine the sense of shared responsibility that increased global cooperation requires.

Although it is difficult to refute arguments of a moral nature, claims such as these contain several flaws. Certainly it makes sense to maintain a moral stigma on pollution when polluters are making a discrete choice whether to pollute. However, in most cases the creation of some pollution is inevitable. Thus the question is not whether we will pollute, but rather how much. In this context it makes sense to evaluate pollution in terms of a tradeoff between the harm it causes and the cost of abating it—and tradable permits allow for this. Furthermore, arguments based on morality seem an inappropriate framework for the debate in light of the past achievements of tradable permits in reducing pollution. For example, it seems strange to debate the morality or immorality of the use of a tradable permit system to phase out leaded gasoline, given that such a system in the 1980s reduced atmospheric concentrations of lead more rapidly than anyone had anticipated, and at a savings of $250 million a year. More generally, the premise that environmental progress must be accompanied by sacrifice is not necessarily valid. Finally, the ability of a tradable permit program to make pollution an internal cost of business is actually very effective, because it forces polluters to incorporate the cost of their external environmental damages into their operating costs.

Myth #2: "Permit markets for pollution are unfair."

It has also been claimed that a market-based system for environmental control is inherently unfair, allowing some participants (those for whom it is less costly to buy permits than to reduce their own emissions) to evade their obligations. For example, a proposal for an emission permit trading program for NO_x in the Netherlands met significant resistance in part because of policymakers' concern that a free initial allocation of credits would benefit the most-polluting companies, while penalizing those that had been more proactive in limiting emissions. But those who oppose pollution permit markets on these grounds overlook the fact that trading usually makes all participants in a regulatory program better off, compared with the same program without trading. Consider the following hypothetical example: Suppose that company A would have to spend $50 million annually to reduce its emissions as required by some new regulation, whereas company B could reduce its emissions by the same amount at a cost of $5 million but is not required to do so. Trade in emissions would make both companies better off. If company A pays company B $30 million in exchange for company B's agreement to reduce its emissions in place of company A, company B would be better off by $25 million, and company A would pay $30 million rather than $50 million to reduce emissions. Indeed, because trade is optional, its mere existence is evidence that trade is beneficial for both parties—if it were not, one party would opt out.

Along the same lines, it is often mistakenly assumed that emission trading somehow favors larger companies, allowing them to buy their way out of pollution reductions whereas smaller companies cannot. But in fact, smaller companies often benefit more from permit markets: because they may not have as many internal options for pollution reduction, the potential to buy emission permits gives them added flexibility. The mistaken assumption that emission trading favors large companies also ignores the distinction between the allocation of permits (and emission rights more generally) and their subsequent trading.

The allocation of permits provides an opportunity to assign responsibility for emission reductions in a way that addresses this concern. For example, one could issue proportionally more permits to smaller companies to reduce their burden. Or one could reward companies that have already reduced emissions by providing them with extra permits. The smaller companies, or the ones receiving extra permits, would then be free either to use the permits themselves—forcing other companies to reduce more—or to sell them if they choose.

Moreover, almost no form of regulation (or, for that matter, of markets) is "fair" under all possible definitions. For example, consider a hypothetical industry in which some firms have invested in newer (more costly) equipment that is less polluting, whereas other firms still use older equipment that is more polluting. Suppose that the government now introduces a regulation requiring, explicitly or implicitly, that all firms in the industry use a third, new technology that is less polluting than either of the first two. Both companies will then have to spend money switching to the new technology. But not only will the firms that originally invested in the intermediate technology receive no benefit from having polluted less in previous years; they will in fact lose more money because they invested in this second-best technology that they now have to discard. Few would consider such a result fair—certainly these firms would not.

To take a real-world example, consider the United States' upcoming ban on methyl bromide. Subsequent to the 1987 Montreal Protocol, participating developed and developing countries agreed to completely phase out the use of this ozone-depleting chemical by 2005 and 2015, respectively. Currently, California strawberry and Florida tomato production relies on methyl bromide to control for pests and weeds. Substitutes for methyl bromide are expected to be less effective and produce lower crop yields. Meanwhile, competing strawberry and tomato growers in Mexico can continue to use methyl bromide for an additional 10 years, thus allowing them to increase their imports to the United States, at the expense of U.S. production. Surely the U.S. farmers would not consider this form of traditional regulation fair.

Finally, those who believe it is unfair for some firms to purchase permits rather than reduce emissions or limit resource use sometimes overlook a feature of a fully tradable permit system that they themselves can take advantage of, to remove permits from the system. If they are unhappy that firms are buying permits in order to comply, they can simply purchase existing permits themselves and retire them, thereby reducing the number of permits available to those firms. This method has been used, for example, by people concerned about wetland preservation to buy water rights from agricultural users in Nevada.

In thinking about fairness generally, society first needs to determine what it believes is fair. Second, groups in society need to remember that those adversely affected by a policy change can in principle be compensated if it is felt that such compensation would make the policy more fair. Compensation can occur under any form of regulatory tool, whether traditional or market based.

Myth #3: "Tradable permits and other flexible mechanisms will never work in the real world."

Flexible mechanisms do work, and we know this from real-world experience: the successful results of many different pollution abatement and resource management programs that have used them. These mechanisms have been shown to be a highly effective (but certainly not the only) means of controlling pollution and managing resources. The case studies below document this experience for a variety of environmental concerns. Although the setup and structure of these programs vary considerably, each has allowed for flexible methods of compliance. As a result, many have achieved their reduction and conservation goals at substantially lower cost than traditional command-and-control approaches. For these programs to work well, however, certain conditions must prevail; these are discussed in greater depth in the section on lessons learned, at the end of the chapter.

Myth #4: "Traditional regulation encourages technological innovation and adoption of new technologies more than do market-based mechanisms."

As discussed above, the circumstances of some environmental issues may favor traditional regulatory approaches, including technological standards mandating the use of a specific technology, and performance standards, which require each firm to demonstrate a certain performance level, expressed as an emission rate per unit of input or output. However, the requirement to use a particular technology prevents firms from seeking out cheaper alternatives. And because individual firms are usually in the best position to find those cheap alternatives, it is likely that technological mandates retard innovation. By specifying compliance in terms of a fixed technology or performance level, both kinds of standards provide little incentive for ongoing improvements in pollution control techniques. That is, firms may get no benefit from improvements they might discover that would allow more emission reductions for the same price. Lacking this incentive, firms may not invest continuously in research and development to enhance environmental quality. Barriers such as these have contributed to declining private sector funding for environmental technology development once firms have met the established standards.

Flexible mechanisms, in contrast, encourage firms to constantly seek out the most cost-effective technology to reduce their pollution. Moreover, the wider technological choice that results from such research creates greater opportunities for still further innovation, which cannot be predicted or captured in a government-controlled technological mandate. One example demonstrating that flexible permit trading programs promote innovation is the success of the Title IV SO_2 program established under the 1990 Clean Air Act Amendments. This program is discussed in greater detail in the case study below. Because the program did not impose a technological requirement, and consequently rewarded all emission reductions, firms began to experiment with blending the high-sulfur coal that many of them had been using with low-sulfur western coal. Blending worked far better than had been thought possible, resulting in low-cost emission reductions.

Because the SO_2 program also included a flexible banking mechanism, firms had an incentive to use these low-cost opportunities to reduce emissions substantially below the required levels. Excess emission reductions such as these are unlikely in programs that limit compliance to a fixed technology or performance level, because they provide no incentive for overcompliance.

As a second example, research shows that stricter building codes have had little effect on homebuilders' choice of insulation technology. On the other hand, higher energy prices and adoption subsidies (which pay homebuilders directly to use more energy-efficient insulation) would have had a much greater effect. In this case, flexible incentives would have led to the more rapid adoption of new technologies, where traditional regulation failed to do so.

Finally, fisheries have long been subject to command-and-control regulation, which, for example, set limits on the time spent fishing. There is strong evidence that, under this type of regulation, fishing operations built up excess capital: too many ships were acquired, and too much equipment was installed, in order to catch as many fish as possible in the short time allowed. In the case of the Federal surf-clam fishery, in contrast, tradable permits succeeded in reducing the number of ships and the amount of capital used, and thus led to a more efficient use of existing technology than the various size limits and time restrictions that they replaced. One of the case studies below discusses fisheries in more detail.

Case Studies in Flexible Environmental Protection

Recognizing that flexible approaches to environmental protection can work solves only part of the puzzle. The other part is identifying the right institutional arrangement for the environmental problem in question, and the right development path along which to build those institutions. Perhaps the best way to understand how flexible programs are put into place is to consider several examples. Below we review three such programs that use varying approaches to address different environmental problems.

The Sulfur Dioxide Permit Trading Program

History of Sulfur Dioxide Regulation

Sulfur dioxide, when released into the atmosphere, reacts with water, oxygen, and other chemicals there to form an acidic deposition known as acid rain. Acid rain has the potential to raise the acidity of lakes, resulting in fish kills; to reduce the alkalinity of forest soils, harming various tree species; and to degrade various other ecosystem functions. Studies have also linked SO_2 with degradation of visibility and with increases in fine particulate matter in the atmosphere, which can cause respiratory problems in humans. In North America, acid rain is a concern mainly in the northeastern United States, particularly in the Adirondacks and New England, and in southeastern Canada. The majority of SO_2 emissions come from industrial activities, although natural sources—volcanoes and sea spray—also contribute.

Historically, SO_2 pollution control has focused on fossil fuel-burning electric power generators, which are responsible for approximately two-thirds of all SO_2 emissions in the United States. The 1970 Clean Air Act Amendments, the first significant Federal air pollution legislation, led to the establishment of national air quality standards for permissible concentrations of SO_2 in the air. States were largely held responsible for meeting these standards in each local area through the development of a State Implementation Plan (SIP), specifying actions to be taken to bring the State into compliance. As part of their SIPs, States required some existing power plants and others not yet built to have high smokestacks, so as to disperse emissions over a wider area. However, because acid rain can sometimes fall hundreds of miles downwind from its source, tall stacks may actually have increased SO_2 concentrations at distant locations. The 1970 amendments also imposed New Source Performance Standards (NSPS), which applied only to new power plants. These standards set new coal-fired plants' maximum allowed emission rates significantly below the emission rates of existing plants.

In projecting States' future air quality, it was assumed that existing plants not meeting the NSPS would gradually be retired, following historical patterns. However, this assumption failed to account for the strong incentives that the rules themselves created to extend the lives of older plants, which were expensive to replace with plants meeting the NSPS. By 1975 it had become clear that, because older plants were continuing to operate longer than expected, many States would not be able to comply with the air quality standards within the mandated time period. As a result, the 1977 Clean Air Act Amendments extended the deadline until 1982 and tightened the NSPS in those areas unable to meet the original deadlines. These new NSPS rules required coal-fired plants built after 1978 to remove a specified percentage of potential emissions. This, however, reduced the advantages of using low-sulfur coal as a means of compliance, because percentage reductions were still required regardless of the type of coal used. Thus regulations may actually have dirtied the air on balance, by encouraging utilities to burn high-sulfur coal and by strengthening the incentives to extend the lives of old, dirty plants. The NSPS requirements also raised fairness issues, as some industries (such as high-sulfur coal producers) benefited while others (such as low-sulfur coal producers) suffered losses. Also among the losers were those States, mostly in the West, that were already using low-sulfur coal to generate electricity and were growing rapidly.

The 1990 Clean Air Act Amendments

Because current controls were not successful at achieving the SO_2 emission reduction goals, a new acid rain program was launched under the 1990 Clean Air Act Amendments. Title IV of the amendments set a goal of reducing annual SO_2 emissions by 10 million tons from the 1980 level. To achieve these ambitious reductions, the law required a two-phase tightening of the restrictions placed on fossil fuel-fired power plants. Phase I, which began in 1995, affected 263 units at 110 mostly coal-burning electric utility plants located throughout 21 eastern and midwestern States. An additional 182 units opted into the program during the course of Phase I. Phase II, which began in 2000, further tightened annual emission limits on the larger, higher emitting Phase I plants and set emission restrictions on smaller, cleaner plants, some of which were fired by oil or natural gas.

To achieve these goals, the 1990 amendments directed the Environmental Protection Agency to design a trading program in SO_2 emission allowances. The program provides incentives for energy conservation and technology innovation that both lower the cost of compliance and increase pollution prevention. Under the program, units are allocated allowances based on their historical fuel consumption and a specific emission rate. The large size and relatively small number of plants made it easier for emissions to be monitored continuously, increasing the credibility of emissions accounting and simplifying verification of the achievement of emission reduction goals. The majority of allowances are allocated by the agency without cost to the recipient. However, every year a small fraction (about 3 percent) of allowances are held back and sold in an auction administered by the Chicago Board of Trade. The SO_2 program also has a reserve of allowances that provides firms with the opportunity to purchase additional allowances at a fixed price of $1,500 (in 1990 dollars; this figure is adjusted each year for inflation). Each allowance permits a unit to emit 1 ton of SO_2 during or after a specified year. Allowances may be bought, sold, or banked for future use. If a plant's annual emissions exceed the number of allowances held, the owners must pay a penalty of $2,000 (in 1990 dollars, also adjusted for inflation) per excess ton of emissions. Violating units are also required to make additional future emission reductions. Trading is not restricted to utility plants; anyone may buy or sell allowances. For example, speculators have acquired some allowances in hopes of future price increases, and environmental groups and some individuals have acquired allowances in order to reduce emissions more than the law requires.

Results

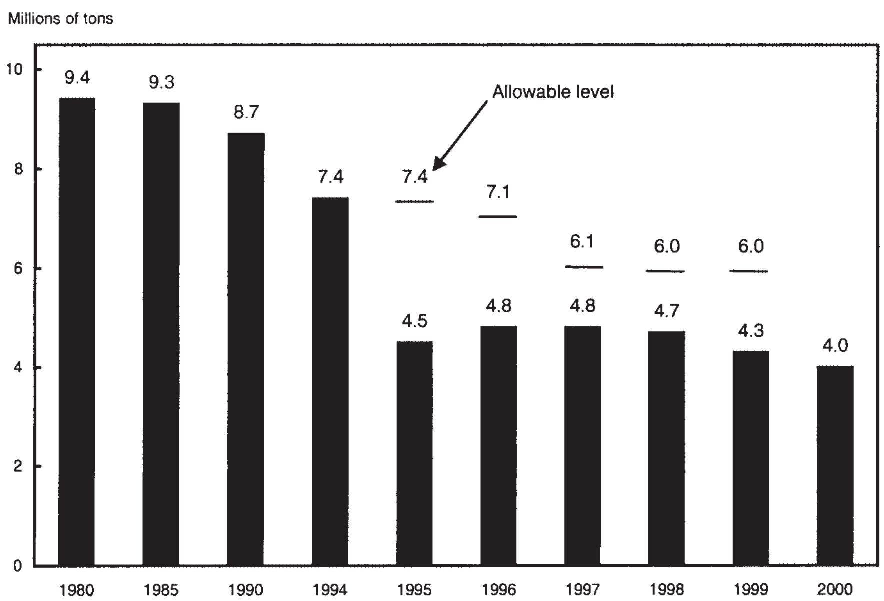
Participation in the trading program has been strong. Through the end of 2000, over 11,600 transfers had taken place, involving 111 million allowances. Approximately 59 percent of these (66 million) were transferred within organizations, and the remainder between economically distinct organizations. Both the number of transfers and the associated number of allowances have increased greatly since the program's inception (Chart 6-4). In the first year of trading (1994), 66 transactions took place, exchanging 0.9 million allowances between economically distinct organizations. In 2000, 2,889 transactions resulted in the transfer of 12.7 million allowances.

The trading program has lowered emissions substantially while yielding considerable cost savings, especially compared with the previous, command-and-control regime. Emissions data indicate that in the program's first target year (1995), nationwide emissions by the units required to participate in Phase I were reduced by almost 40 percent below their required level (Chart 6-5). This overachievement was encouraged by the provision allowing firms to bank credits for future use when they reduce emissions in excess of current requirements. The General Accounting Office projects that, compared with the command-and-control approach, the allowance trading system could save as much as $3 billion a year, or more than half the total cost of meeting the standards. Some economists, however, believe this estimate overstates the program's cost reduction. As low-cost options for emission reduction emerged that had not been foreseen in 1989, there has been over time a clear downward trend in the predicted cost of the program. This primarily results from the fact that, as it turned out, low-sulfur coal could be substituted for high-sulfur coal much more easily than had been anticipated at the program's inception. On the other hand, this less costly method was likely adopted, in part, precisely because of the flexibility allowed for in the SO_2 trading program. A command-and-control program, whether based on performance standards or on technological requirements, might have afforded much less opportunity to take advantage of this low-cost alternative. In this case, flexibility allowed adoption of the optimal, most efficient solution available.

Chart 6-4 **Sulfur Dioxide Allowances Traded Between Economically Distinct Organizations**
Trading activity in the sulfur dioxide emissions permit trading program has risen almost without interruption.

Source: Environmental Protection Agency.

Chart 6-5 **Emissions from Phase I Facilities in the Sulfur Dioxide Trading Program**
Sulfur dioxide emissions from the original 263 units were far below allowable levels during Phase I.



Source: Environmental Protection Agency.

Tradable Quotas in the Alaskan Halibut and Sablefish Fisheries

The preceding example focused on a national pollution problem, which required a national solution. But flexible approaches have also been successfully applied to local and regional environmental problems, as the next two case studies demonstrate.

Fish in the coastal waters and open seas are the private property of no one; they are there to be caught by anyone with a boat, a fishing permit, and the necessary equipment. This public access nature of saltwater fisheries results in economic inefficiencies. If fish could be fenced in and counted like cattle, property rights could be allocated for each fish, or for a school, or for an entire fishery. Owners of such rights would have an incentive to limit their catch, so that enough fish are left each year to ensure the sustainability of the fish population, and thus of the owners' profits, in future years. However, because rights to individual fish or to fisheries cannot be established, and no one private fishing operation can control the actions of others, it is often in each fisherman's best interest to catch as many fish as possible, as quickly as possible, before the others do. As a result, many fisheries have suffered from an excess of capital, participation, or effort given the amount of fish available. This, in turn, has led not only to overfishing and depletion of the resource, but also to increased conflict and hostility, undesirable price and market effects, and increased physical danger to fishermen.

Regulation of U.S. fisheries was established in 1976 with the passage of the Fishery Conservation and Management Act (later renamed the Magnuson-Stevens Fishery Conservation and Management Act). Since then the act has been amended more than a dozen times, marking significant changes in its course and emphasis. The 1996 amendments emphasized the goal of biological conservation of fish stocks and protection of habitats, along with other resource management objectives. For the first time, the amendments made the prevention of overfishing an enforceable obligation on the part of the Federal Government.

In some fisheries, authorities have sought to achieve these goals through the use of a market-based output control mechanism called individual fishing quotas (IFQs, sometimes also called individual transferable quotas). An IFQ is defined as "a Federal permit under a limited access system to harvest a quantity of fish, expressed by a unit or units representing a percentage of the total allowable catch (TAC) of a fishery that may be received or held for exclusive use by a person." Ideally, regulators should set the TAC equal to the socially optimal catch (that is, the maximum sustainable catch). To date, IFQs have been adopted in a number of U.S. fisheries, such as those for surf clams and ocean quahogs, South Atlantic wreckfish, and Alaskan halibut and sablefish. Such mechanisms have also been used in other countries, including Iceland and New Zealand.

The experiences of the Alaskan halibut and sablefish fisheries are particularly illustrative. When the IFQ program was launched in 1995, the estimated coastwide biomass of halibut was above the 25-year average, but was declining and expected to continue to drop in the future. As of 1999, sablefish biomass had been declining since 1986 and was 30 percent below the recent average. Before the IFQ program, efforts to maintain fish stocks took the form of traditional management: regulators set an annual TAC on commercial fishing of halibut and then attempted to achieve the TAC through a combination of area, season, and gear restrictions. These regulations resulted in a host of problems, such as gear conflicts, fish kills due to gear lost at sea, discarded fish mortality, excess harvesting capacity, declines in product quality, safety concerns, unmonitored catch of regulated species in other fisheries, and economic instability within both the fishing industry and fishing communities. Evidence of some of these problems can be seen in the extremely short annual season for halibut fishing: from 1980 to 1994 the season averaged only 2 to 3 days in the management areas responsible for the majority of catches.

IFQ Design

Consideration of limits to entry began in 1977, but because of implementation delays, IFQs for halibut and sablefish were not approved until the end of 1991 and were implemented only in 1995. A primary objective of the program was to eliminate the fishing derby associated with the shortened season and the limit on the catch. This frantic race for fish was not only unsafe but inefficient as well. To increase their individual catch, some fishermen brought in additional vessels, and this imposed higher costs both on themselves and on others. These higher costs included increased harvesting and processing costs and decreased product prices, as well as the potential for higher debt service, additional unmonitored fish mortality, and increased accidents.

The design and management of the IFQ programs for Alaskan halibut and sablefish are largely the same. Landing data for halibut are collected by individual State governments and then forwarded to the International Pacific Halibut Commission (IPHC). Catch data for sablefish are collected by the individual States and the National Marine Fisheries Service (NMFS). Both programs require IFQ owners to be on board the vessel when the IFQ is being fished. They also set limits on the accumulation and transfer of quota shares. No person may own more than 0.5 percent of the total quota share for halibut, or 1 percent of the share for sablefish, in particular areas. Transferability is restricted across vessel size and across vessel categories.

IFQs were allocated to vessel owners and leaseholders who had verifiable commercial landings of halibut or sablefish during any of the eligibility years

1988, 1989, and 1990. Specific allocations were based on the best 5 years of landings during the qualifying years of 1984-90 for halibut and 1985-90 for sablefish.

The catch is monitored through a combination of real-time and post-transaction auditing. Deliveries may be made only to registered buyers, and notice must be given to the NMFS. Real-time auditing is through IFQ landing cards and transaction terminals. Post-transaction auditing compares the records submitted by registered buyers with the fishermen's landing records. Provisions also exist for over- and underharvests: limited amounts of annual quota shares can be either deducted or credited to the next year's allocation. In part because of this extensive monitoring system, administration of IFQ programs is somewhat costly. Nevertheless, it is believed that the program's economic benefits will far outweigh the increase in management costs. In addition, as mandated by the new Magnuson-Stevens Act requirements, a cost recovery program to help defray monitoring and enforcement costs was established in March 2000.

Results

Measured against the program's stated goals, IFQs for halibut and sablefish have been highly successful. Most notably, the race for fish was eliminated. The season has increased from less than 5 days to 245 days a year for both species, and landings are now broadly distributed throughout the season. As a result, safety has improved. The program also reduced the frequency with which the TAC was exceeded, in both fisheries. In addition, the IPHC estimates that discarding of halibut bycatch fell by about 80 percent between 1994 and 1995, as did halibut mortality from lost or abandoned gear (although significant uncertainty surrounds both these estimates). There does not, however, appear to be any difference in sablefish bycatch before and after IFQ implementation. There is anecdotal evidence of highgrading (discarding all but the most profitable fish), but comparisons of halibut size-composition data suggest that any highgrading that does occur is insignificant. Underreporting of either halibut or sablefish catches does not appear to be a problem.

Meanwhile the quota share markets have been active, with more than 3,800 permanent transfers of halibut quota shares to date and more than 1,100 transfers of sablefish quota shares. Trading under the IFQ program has also led to some consolidation: the number of quota holders declined by 24 percent for halibut and 18 percent for sablefish between January 1995 and August 1997. In both fisheries the bulk of this consolidation has taken place among those with smaller IFQ holdings. Although it seems likely that the overall efficiency of the fisheries has increased, it remains uncertain how costs and revenues have been affected.

Despite these successes, some concerns remain. Most complaints center on the allocation of IFQ permits, while the rest tend to reflect problems common to any fishing restriction. The primary complaint concerning the initial allocation relates to the delay between the qualifying years and the implementation of the program. Some fishermen who have become active since the qualifying years received no initial free allocations and had to purchase all their quota rights. Conversely, some quota shares were awarded to individuals who had been active during the qualifying years but inactive in the years immediately preceding implementation. Crewmembers and processors also allege that the initial allocation rewarded vessel owners and redistributed market power in favor of quota shareholders. In addition, there is ongoing concern about community effects, adequacy of enforcement, the potential for localized depletion, and the preemption of productive sportfishing grounds (which are not regulated) by commercial fishermen. Many of these issues could plague any fishing regulation scheme.

Informal Permit Trading in the Tar-Pamlico River Basin

In 1983 local fishermen and citizens in the basin of the Tar and Pamlico Rivers of eastern North Carolina noticed sores on fish, algal blooms (aquatic algae consuming the water's available oxygen), and fish kills in their local rivers and estuaries. Because studies link many of these problems to increased concentrations of phosphorus and nitrogen in water systems, the North Carolina Environmental Management Commission (EMC) designated the region a Nutrient Sensitive Water in 1989.

Laying the groundwork for future regulation was somewhat complicated by the fact that these nutrients came from different types of sources: 83 percent of nitrogen and 66 percent of phosphorus loads originated from non-point sources, such as agricultural runoff and natural phenomena. The remainder came from point sources such as water sewage treatment facilities and local industry. Given the political and technological constraints on detecting, monitoring, and enforcing non-point source nutrient reduction, the proposed EMC regulation targeted point source discharges, setting strict limits on new dischargers and the expansion of existing ones. The ultimate goal of this command-and-control regulation was to reduce phosphorus and nitrogen loading into the region's waters by 200,000 kilograms a year by 1995.

Some of the publicly owned treatment works (POTWs) affected by the regulation estimated that together they would have to spend between \$50 million and \$100 million to achieve compliance with the State's plan.

Concerned about these high capital costs, the POTWs, in conjunction with a private firm, asked the North Carolina State government if a better solution could be found. Working with the Environmental Defense Fund (a private nonprofit group, now called Environmental Defense) and the Pamlico-Tar River Foundation, a coalition of dischargers called the Tar-Pamlico Basin Association proposed an alternative solution involving collective nutrient trading.

Under the arrangement, which was approved in 1989, two types of trades are allowed: collective trading among point sources and collective trading between point sources and non-point sources. In the first case, members of the association operate within a "bubble," offsetting one another's discharges to achieve a specified overall limit. In the second case, the members collectively have the option to achieve all or part of the total nutrient reduction goals by funding agricultural best management practices (BMPs) through the State's Agricultural Cost Share Program, which pays farmers to reduce nutrients and runoff. These offset funds are used to pay willing farmers 75 percent of the cost of adopting nutrient-reducing BMPs on farms within the basin. In this manner the Tar-Pamlico program establishes responsibility at the group rather than the individual level, as no transactions occur between individual point source and non-point source polluters.

So long as the association succeeded in reducing phosphorus and nitrogen emissions by the originally targeted 200,000 kilograms a year, no specific emission reduction requirements would be imposed. Given this flexibility, the association estimated that it could meet this reduction for about $11.5 million, far less than the estimated cost of the proposed command-and-control regulation. The agreement between the association and the State also required the association to fund a computer model simulating nutrients' flow and effects; to hire a consultant to evaluate existing wastewater treatment plants, to determine the changes needed to ensure that they are operating at maximum efficiency; to monitor each member's weekly phosphorus and nitrogen discharge; and to provide upfront funding for the Agricultural Cost Share Program.

In all, 15 dischargers, contributing about 90 percent of all point source flows to the basin, eventually joined the association. Some of those that decided not to join cited the risk involved: there was no guarantee that the association would achieve the required nutrient reduction by 1995. If it failed, the investment and membership costs would be forfeited, and the State's original command-and-control plan would be implemented. Other point source dischargers that had already planned or begun upgrades in plant facilities could meet the State's stricter limits without the need to trade.

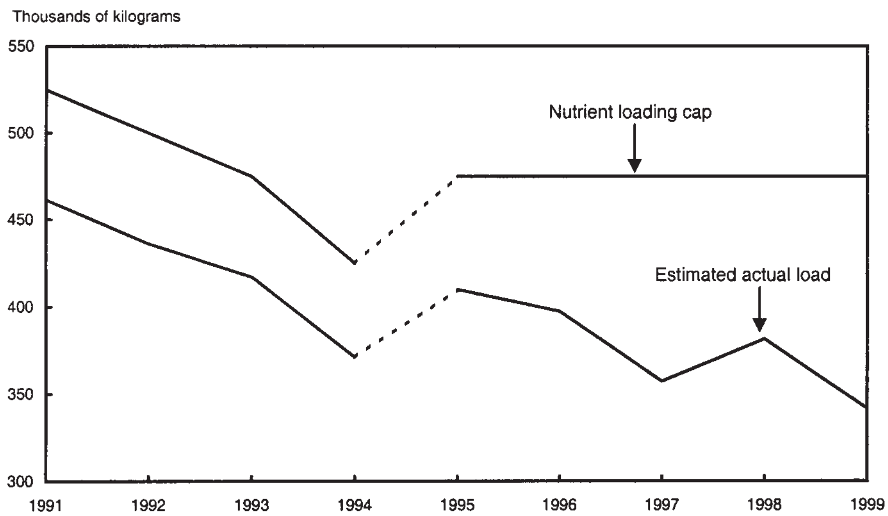
A tricky feature of this program is the arrangement for trading between point and non-point sources. Whereas the amount of nutrient load entering the water from a point source is easily measurable, that from a non-point source is not. This is in part because the amount of nutrient loading resulting from a given amount of fertilizer can vary considerably, depending on the weather and other conditions outside anyone's control. Because of this added uncertainty, expected non-point source emissions are imperfect substitutes for point source emissions: more than one unit of non-point source reductions is necessary to equal, in quality-adjusted terms, a unit of point source reductions. It was recognized that, because of this, trades between these two types should not occur at a one-to-one ratio. But it was also recognized that the choice of the trading ratio between point and non-point sources would be key to the program's success: too high a ratio would discourage trading, but too low a ratio might fail to achieve abatement goals. In the end, the trading ratio was set at two to one for effluents from non-point sources involving livestock (such as pastureland and poultry operations), and three to one for cropland. That is, to acquire a one-unit credit, the association must pay the State's Agricultural Cost Share Program for the reduction of two (or three) units of a non-point source's nutrient emissions.

To date, compliance has been achieved entirely through trade among point sources. It is uncertain whether this indicates that the trading ratio was set too high, or that abatement costs at point sources are in fact the lowest-cost alternative. But an important outcome is that, thus far, internal "trades" have taken place rather informally. Instead of paying one another to undertake pollution control measures, association members reportedly have each agreed to incorporate nutrient removal systems whenever they expand their facilities. The association maintains that this approach is less costly: economies of scope make it less expensive to expand a facility and upgrade the control technology simultaneously, rather than on separate occasions as trading might require.

The two largest emitters in the group, both POTWs, were among the first to implement nutrient removal systems. Smaller members have since followed suit. The association expects to achieve the reduction requirements through internal trading for the next 4 or 5 years, after which members may begin to take advantage of trading with non-point sources, or shift to a more formal trading system within the organization, or both.

The results of this market-based program have been impressive (Chart 6-6). Because of growth in nearby communities, dischargers have had to become even more efficient with respect to their nutrient emissions. Even though the association's combined discharge flow increased approximately 20 to 35 percent from 1991 to 1997, total nitrogen concentrations fell by 10 to 20 percent, and total phosphorus concentrations by 20 to 40 percent, in the same period.

Chart 6-6 **Nutrient Loading by the Tar-Pamlico Basin Association**
The association's nutrient loads under the market-based nutrient reduction program in this North Carolina region have remained well below loading caps.



Note: Nutrients measured are nitrogen and phosphorus. The periods 1991-94 and 1995-99 represent two distinct phases of the program.
Source: North Carolina Department of Environment and Natural Resources (Division of Water Quality).

When Markets Don't Work

The preceding case studies highlighted three examples where flexible, market-based approaches have been used to achieve environmental goals at substantial savings over less flexible alternatives. In each case the institutions and their historical development differed substantially. An important lesson is that these different settings required different approaches in order to succeed.

In other words, flexible approaches do not succeed simply by virtue of their flexibility. Other elements are necessary as well. First, tradable permit markets typically require a large number of participants to work well. As the Tar-Pamlico case study suggests, one way around this dilemma of a small number of participants may be to create a more informal trading association. Second, it is important that trading not be inhibited by overly cumbersome restrictions. For example, in 1981 the Wisconsin Tradable Discharge Permit system was organized on the Fox River, allowing rights to biochemical oxygen demand discharges (which decrease the oxygen available for fish and other aquatic species) to be traded among point sources. By 1996, however, only one trade had taken place. It is likely that trading was infrequent because administrative impediments discouraged the transfer of permits. Dischargers are not allowed to trade unless they can demonstrate need, and therefore they cannot trade solely for the purpose of reducing treatment costs. Moreover, the traded rights are guaranteed for a maximum of 5 years, with no assurance that rights will be renewed.

In addition to liquidity among participants at a given moment, liquidity across time is necessary to smooth out temporary fluctuations in aggregate permit demand. For example, the SO_2 trading program allows firms to bank unused permits for future use. By 1996, after just 2 years of operation, the total volume of banked permits actually exceeded annual emission levels. This bank provides an effective cushion against demand fluctuations, as the banked permits can be increased or drawn down as needed. In contrast, the Los Angeles area NO_x program initially lacked a permit bank or other source of aggregate flexibility. As a consequence, the permit price skyrocketed from its historical level of around $2 a pound to nearly $50 a pound in the summer of 2000, because of increased demand from fossil-fuel electricity producers. Similarly, an innovative internal greenhouse gas emission trading program at a major energy company has seen fluctuations in demand cause the price to jump to $99 per ton of carbon dioxide in less than 1 year from almost zero the year before, in the absence of a substantial bank. These aggregate liquidity problems could be solved either by developing a bank or, as suggested above, by empowering the regulatory agency to provide a safety valve, selling additional permits when the price reaches a specified threshold.

Finally, flexible programs work best when monitoring costs are low and when financial incentives—fees or permit requirements—are easily associated with actual emissions or resource use. Automobile emissions, for example, are poor candidates for a trading program: it is impractical to require the drivers of the Nation's more than 100 million registered automobiles to both monitor their individual emissions and acquire tradable permits accordingly. Still, we see flexible approaches—in the form of tradable performance standards described earlier—applied to these sources.

Lessons for Future Policy: Climate Change

One of the most controversial and complex environmental policy challenges facing the United States—and the world—is the long-term issue of climate change. This potential problem spans both generations and countries, implicating simultaneously the environment, on the one hand, and the world's fundamental economic reliance on fossil fuels—a key source of climate change risk—on the other. What do the lessons learned in this chapter suggest about a reasonable approach to climate change?

Base Policy Action on Sound Science

In each of the case studies presented in this chapter, government policy responded to an environmental problem in a manner designed to protect not only the environment but also economic well-being. Sound science guided those responses and must do so in our response to climate change, as articulated by the President in his speech in the Rose Garden on June 11, 2001. Yet the risks arising from climate change are less clear than the risks identified in the case studies, as is the appropriate response. We are uncertain about the effect of natural fluctuations on global warming. We do not know how much the climate could or will change in the future. We do not know how fast climate change will occur, or even how some of our actions could affect it. Finally, it is difficult to say with any certainty what constitutes a dangerous level of warming that must be avoided.

Therefore an important element of a reasonable climate change approach must be more research into both the science of climate change and mitigation technologies, in order to learn more about the risks and the appropriate response. The President has committed the United States to do just that, with research initiatives in both the science of understanding climate change and the means of mitigating its effects. This includes the President's Climate Change Research Initiative and his National Climate Change Technology Initiative, which will add to the more than $18 billion spent on climate research since 1990.

Choose a Flexible, Gradual Approach

The President has also directed an effort to consider approaches to reducing greenhouse gas emissions. All of the case studies in this chapter demonstrate that flexible approaches consistently provide environmental benefits at a lower economic cost than traditional methods. Flexibility is even more important when balancing climate change and fossil energy use. An effective program must include all greenhouse gases, all emission sources and sinks, and, given the global nature of the problem, all countries. It should provide for flexibility to shift emission reductions over time in response to both short- and long-term opportunities. Flexibility is needed in the face of changing economic conditions, scientific uncertainty, and the development of affordable, advanced energy and sequestration technologies. Finally, an effective program needs to consider non-greenhouse gas emissions that contribute to climate change, such as tropospheric ozone and black soot. Because all of these dimensions offer promising opportunities to address climate change, each must be used in a way that maximizes the mitigation benefit for every dollar spent.

Ideally, this could be accomplished by creating the same incentives for equivalent emission reductions in all these different dimensions: across gases, across sources, across countries, and over time. These incentives would necessarily adjust in response to changing economic conditions and additional knowledge concerning benefits and costs. Yet concepts such as a worldwide tax on greenhouse gas emissions or a worldwide tradable permit system, sometimes advertised as solutions, are at best useful theoretical benchmarks against which to measure alternative, practical approaches. At worst, they can be a distraction from meaningful, realistic steps forward.

Why are such proposals impractical? Because they fail to recognize the enormous institutional and logistical obstacles to implementing any sweeping international program. Institutionally, it is important to learn to walk before trying to run. The United States implemented its successful SO_2 trading program only after gaining experience in the 1970s and 1980s with netting and banking programs, experimenting with control technologies for more than 20 years, and recognizing the limitations of alternative command-and-control approaches. Most other countries have significantly less experience with flexible approaches. A flexible international program would be unprecedented.

As the case studies have also shown, flexible programs have been remarkably successful—but sometimes they run into glitches. For that reason, it would be dangerous to make any serious U.S. policy or commitment dependent on newly designed and untried international institutions—a point highlighted by the President's Cabinet-level climate change working group in its initial findings. Moreover, the current uncertainty surrounding climate change implies that a realistic policy should involve a gradual, measured response, not a risky, precipitous one.

What would constitute a practical policy? In addition to the science and technology initiatives noted above, we could begin investigating reasonable ways to set emission goals and to facilitate efforts by businesses and individuals to think about their own emissions and opportunities for reductions. Internationally, we should continue to expand our cooperation with both developed and developing countries. This will build experience along the various dimensions required for a flexible response and will set the institutional foundation for any further policies that might be necessary in the future.

Set Reasonable, Gradual Goals

A reasonable national goal for greenhouse gas emissions could serve as a benchmark for our progress in terms of mitigation, and thus as an investment in one aspect of a climate change policy that encompasses science, technology, cooperation, and mitigation. One of the problems with climate policy over the past decade has been a focus on unreasonable, infeasible targets. For example, reducing U.S. emissions to 7 percent less than their 1990 level (the Kyoto target) over the next 10 years could cost up to 4 percent of GDP in 2010—a staggering sum when there is no scientific basis for believing this target is preferable to one less costly. Worse yet, by imposing such high economic costs and diverting limited resources, the Kyoto targets could have reduced our capacity to find innovative ways out of the environmental consequences of global warming. But what defines a reasonable emission goal in the absence of better science?

The uncertainty surrounding the science of climate change suggests that some modesty is in order. We need to recognize that it makes sense to discuss slowing emission growth before trying to stop and eventually reverse it. There is an unfortunate tendency to treat greenhouse gases—especially carbon dioxide (CO_2)—in a manner analogous to SO_2 and NO_x, for which strict quantitative limits have been imposed. SO_2 and NO_x can be controlled by adding equipment to existing facilities. CO_2, however, can only be reduced by either reducing energy use or replacing fossil fuel facilities, equipment, and transportation fleets with ones that use fuels with lower or zero emissions (that is, unless and until capture and sequestration of CO_2 become feasible). This is vastly more expensive than the end-of-pipe treatment appropriate for SO_2 and NO_x, and it raises concerns about fuel diversity, national security, and the ability to sustain our economic strength and quality of life.

A modest, near-term goal to mitigate greenhouse gas emissions could be described in many ways. A greenhouse gas emission target could be indexed to economic output or other measures of economic activity. Or one could express the goal in terms of greenhouse gas emission intensity, that is, the amount of emissions per unit of economic activity. Both these ideas describe targets that are flexible in the face of economic growth, encouraging reductions without threatening the economy.

A reasonable, gradual goal specified in this way offers advantages over the reductions set out in the Kyoto Protocol. The Kyoto Protocol focused on rather dramatic short-term reductions with unclear environmental benefits. Those reductions risked damaging economic consequences and, in turn, jeopardized the ability to invest in long-run scientific and technological solutions. A reasonable goal offers insurance consistent with existing climate science without putting the economy at risk. A gradual approach balances the need for mitigation with the need for economic growth to power future innovation. A gradual approach also allows us to adjust as we learn more from the science and are able to take advantage of technologies as they develop. Finally, a gradual goal provides time to develop stronger institutions for a long-term, global solution.

Provide Information and Encourage Reductions

In addition to setting a reasonable goal, we need to facilitate efforts by firms and individuals to track their own behavior and to recognize cost-effective mitigation opportunities. The government has a useful role here, both in providing information and in acknowledging progress. No matter how sensible the near-term national goal, firms and individuals need to understand their role—and opportunities—in order to succeed.

One portion of an information program could be the development of procedures and pilot programs to measure both project-based reductions and carbon sequestration. Project-based measurement is important domestically to the extent that offsets are eventually used in certain sectors or for certain gases. It is important internationally if the United States wants to encourage domestic firms to seek out meaningful reductions in developing countries where fully market-based programs are unlikely to be implemented.

Sequestration of greenhouse gases in agricultural and forestry sinks offers considerable opportunity, both domestically and internationally, to achieve inexpensive near- and medium-term reductions—if an environmentally sound accounting method can be devised. We can continue work aimed at reducing the concerns and uncertainty associated with sink usage. In all cases, research, rules, and pilot programs should be developed in consultation with other countries pursuing alternative climate change programs, to ensure both consistency and fair competition.

In addition to educating businesses and individuals about their own greenhouse gas emissions and the opportunities to reduce them, we can encourage them to reduce emissions in innovative ways. This might involve incentives, voluntary challenges, or public recognition, again focusing on flexible, gradual efforts.

Give Technology—and Institutions—Time

These first steps concerning reasonable goals, information, and accounting, along with continued international cooperation, can serve as building blocks toward long-term institutions. To get the institutions right and to protect the economy, however, this movement must be gradual. Initial steps should signal our intent and thereby encourage the development of new technologies—technologies designed to eventually stabilize atmospheric concentrations of greenhouse gases at a level that does not dangerously interfere with the climate system. Such stabilization, in contrast to an arbitrary short-term emission limit, remains the long-term goal recommended both by the United Nations Framework Convention on Climate Change and by the President.

These efforts and goals will require time in order to accomplish them effectively. Science, markets, technology, and global participation must be wound together in an effective policy response. To do so requires building sound institutions for a better environment.